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(54) Title of invention: Forming method of resist pattern

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(72) Inventor: Hiroyuki Matsui
Dainippon Printing Co., Ltd.
1-1-1 Kagacho, Ichigaya, Shinjuku-ku, Tokyo
(72) Inventor: Seitaro Tsutsumi
Dainippon Printing Co., Ltd.
1-1-1 Kagacho, Ichigaya, Shinjuku-ku, Tokyo
(71) Assignee: Dainippon Printing Co., Ltd.
1-1-1 Kagacho, Ichigaya, Shinjuku-ku, Tokyo
(74) Attorney: Isamu Hosoi, Patent attorney

PATENT SPECIFICATION

1. TITLE OF INVENTION
Forming method of resist pattern

2. CLAIM
(1) A forming method of resist pattern which is characterized by; opposing a master pattern provided with valley sections with a pattern shape corresponding desired resist pattern, and a substrate on which the resist patter is to be formed, with hardening resin for resist located between them; sandwiching the hardening resin by applying a pressure on the master pattern and the substrate from both sides; then curing the hardening resin by irradiating heat or electromagnetic radiation followed by releasing the master pattern to form a patterned relief layer comprising the hardening resin on the substrate; and after this by uniformly etching entire surface to completely remove the hardened resin at the valley sections of the relief layer, and form a resist layer comprising the remaining hardening resin at the peak sections of the relief layer.
(2) A forming method of resist pattern that is described in Claim 1 and is to form a patterned relief layer having a ratio of the thickness of peak section A and the thickness of valley section B (A/B) being 1.2/1 or more.
(3) In the resist pattern forming method that is described Claim 1, a forming method of resist pattern which is characterized by using polymerizing monomer or a mixture of the monomer and hardening resin, in place of the hardening resin.

3. DETAILED DESCRIPTION OF THE INVENTION

[Field of industrial applications]
This invention concerns forming method of resist patterns which is applied when various patterning is done on a substrate or a layer on a substrate with such as etching.

[Prior technologies and the problems that the invention is to solve]
Patterning has been applied by such as etching in various fields in semiconductor industries and others, and photo-lithography method has been generally known as a forming method of forming resist patterns that is done prior to the application of etching. This photo-lithography method is to coat photo-resist on the material-to-be-worked, than after applying a treatment to improve contact between the photo-resist and the material-to-be-worked by pre-baking, apply ultraviolet light exposure through a mask having a desired pattern, and then selectively dissolve to remove either exposed part or un-exposed part of the photo-resist with specific development solution, to form a resist pattern.
However, this photo-lithography method has extremely many processes which is obvious from the fact that this process requires at least a process to wash the material-to-be-worked such as substrate, a process to coat photo-resist on the material-to-be-worked, pre-baking process to improve the contact between the material-to-be-worked and coated photo-resist, and exposure process to expose ultraviolet light through a specific mask, development process to selectively remove one of the exposed part or un-exposed part of the resist using the difference of dissolving property of them into development solution, and further, post baking process that is to harden the resist by heat treatment as required may be applied; and finally etching process is applied after the completion of these processes; and any of the processes require relatively advanced handling

and high skills.

For example, because existence of a fine foreign object in a size of one tenth of the size of the minimum size of resist pattern to be applied will be a cause of pattern defect, precise and secure washing is necessary and extraordinary caution and control system is needed in all of the series of processes after the washing against foreign objects from contaminating or attaching. At the coating process, the photo-resist must be coated in uniform thickness, and a coating apparatus that is able to do that precise coating is necessary, and the coating condition must be strictly managed. In the exposure process, an exposure optical system that generates parallel light is necessary in order to highly precise exposure through a mask, and apparatus that has this type of optical property, especially the one that has greater than 30 cm square is extremely precise and expensive apparatus. As the more precise optical system, a projection exposure optical system is currently used that uses lenses and mirrors, however, the effective exposure area of maximum 15 cm square is the limit, and it is more precise and expensive apparatus than above described parallel light type. In the development process, an apparatus is needed that is able to well control such as contact level of the development solution to the object-to-be-processed and sufficient management is needed, in order not to cause variation in the degree of development.

Further, the photo-lithography method is able to form patterns from tens of micro meters to hundreds of micro meters in the field of metal etching of such as shadow masks that has relatively large pattern size, and is able to form patterns one micro meter or less in the field of such as LSI that has smaller pattern size, however, it requires extremely special and expensive equipment and especially the process for large substrate and others has severe limitations in equipment and the equipment itself is further more expensive.

As described in above, although the photo-lithographic method is able to form highly precise and fine resist patterns, there are various problems that there are large limitations in apparatus and the apparatus are expensive, and there are many process stapes and long.

On the other hand, as a means to conduct the forming of the resist pattern in relatively large handling capacity and with relatively low cost apparatus, the printing method has been known. For example, in the production field of such as print circuit boards, silk screen printing has been used and this type of printing method has been applied for such as the forming of soldering resist pattern, as well as the forming of resist patterns for etching.

However, it is very difficult to form fine patterns with these printing methods, and for example it is not able to print and form patterns in 100 μm or less line width with said silk screen printing method, and even with other printing methods situation is similar. Therefore, although apparatus and process will be simplified with the printing method compared with said lithography method, there is a drawback that there is a significant problem in preciseness of obtained resist pattern, and especially it is not able to make fine patterns.

[Means to solve the problems]

The inventors and others have proceeded with an investigation for solving the problems of said previous technology, and as a result they discovered that, a forming method (photo-polymer method) that is able to form micro fine pattern, able to use simpler equipment, and able to make high precision patterns with relatively simple process, is able to be used as a production method of resist pattern replacing previous photo-lithography method or printing method, and they continued the investigation based on this knowledge.

Above described photo-polymer method is a forming method that is to insert an electromagnetic radiation curing resin such as ultraviolet light or electron beam curing resin

between base material and a forming pattern, and to cure said resin by irradiating electromagnetic radiation to obtain formed material that is applied with desired relief pattern on its surface by the forming pattern, which has been generally used as a technique for replicating relief shapes and it is able to exactly replicate a pattern of relief shape in a size of even smaller than 1 μm. Therefore, in recent years, technologies have been proposed which are applied for the replication of hologram sheet or production of optical memory sheet and lens sheets such as prism lens sheet.

However, this technique has it objective to strictly reproduce the shape of relief, and of course it is impossible to directly apply this method for forming resist patterns, therefore, we did various investigations on those points to reach this invention.

Namely, this invention has its essential points as;

(1) a forming method of resist pattern which is characterized by; opposing a master pattern provided with valley sections with a pattern shape corresponding desired resist pattern, and a substrate on which the resist patter is to be formed, with hardening resin for resist located between them; sandwiching the hardening resin by applying a pressure on the master pattern and the substrate from both sides; then curing the hardening resin by irradiating heat or electromagnetic radiation followed by releasing the master pattern to form a patterned relief layer comprising the hardening resin on the substrate; and after this by uniformly etching entire surface to completely remove the hardened resin at the valley sections of the relief layer, and form a resist layer comprising the remaining hardening resin at the peak sections of the relief layer,

(2) A forming method of resist pattern that is described in Claim 1 and is to form a patterned relief layer having a ratio of the thickness of peak section A and the thickness of valley section B (A/B) being 1.2/1 or more, and

(3) in the resist pattern forming method that is described Claim 1, a forming method of resist pattern which is characterized by using polymerizing monomer or a mixture of the monomer and hardening resin, in place of the hardening resin.

[Embodiment examples]

In the following, embodiment examples of this invention is explained based on drawings.

Figure 1 is a cross sectional explanation drawing of each process showing an embodiment example of the method of this invention, and Figure 2 is a cross sectional explanation drawing of each process showing another embodiment example of the method of this invention. In the drawings, 1 is master pattern, 2 is valley section in a shape of pattern corresponding to the resist pattern that is located on the master pattern 1, 3 is substrate on which the resist pattern is to be formed, and 4 is hardening resin for resist. In this invention, forming of similar resist pattern may be also done by using polymerizing monomer or a mixture of polymerizing monomer and hardening resin, in place of the hardening resin 4.

Above described master pattern 1 is made by using glass plate, plate or film of plastics such as acrylic resin, PET, polycarbonate and polyether, or metal plate of such as stainless steel and aluminum as the substrate, and desired pattern is directly machined or etched with etching method in this to form the valley section 2, or with said photo-polymer method to form the valley section 2. As the substrate, rather flexible materials such as plastics or metal plate than stiff ones such as glass, are easier in releasing later described process of the master pattern. Although easy release is possible even with using glass by a combination of materials. Also it is able to coat releasing agent on the side of the valley section 2 or directly impregnate into the resin base material in order to make the releasing work of the master pattern 1. As the releasing agent, it is

able to mention that silicone oil, higher aliphatic acids such as stearic acid and their metal salts may be used, and in concrete, it is able to mention Gafak* RB410, Gafak* RL210, Gafak* RD510 (above made by Toho Chemical), Prisurf* 217E, Prisurf* A-2085 (above made by Daiich Kogyo Seiyaku), and Lastin* (made by Ajinomoto).

** Translator's note: All these brand names are phonetic translation and the original spellings in English are not certain.*

The substrate 3 is not limited within specific for its material. The substrate 3 as shown in drawings are all known ones provided with an etching layer 13 on them.

As the hardening resin 4 for resist that is sandwiched between the master pattern 1 and the substrate 3, such as electromagnetic radiation curing type resins such as electron beam or ultraviolet light curing resin and heat curing type resins are mentioned. The electromagnetic radiation curing type regin generally hardens by acrylic type double bond polymerization reacting with the energy of ultraviolet light or electron beam, and in concrete as electron beam curing type, it is able to use such as Goselac* UV7000B and Goselac* UV4200T (above made by Nippon Gosei), and Diabeam UK6034 and Diabeam UK6033 (above made by Mitsubishi Rayon). Also, when ultraviolet light curing it is necessary to add a small amount of photo-reaction initiator to those, and it is able to use such as Darocure* 1173, Darocure* 1115 and darocure* 953 (above made by Merk), Irgacure* 184, Irgacure* 500 and Irgacure* 651 (avove made by Tegabagy**), as the concrete ultraviolet curing types.

**Translator's note: All these (brand) names are phonetic translation and the original spellings in English are not certain.*

***Translator's note: This "Tegabagy" is a phonetic translation of what it is written in Japanese, however, correct name shall be "Ciba Geigy".*

Further, monomers as reactive thinner may be added in appropriate amount to the hardening resin 4 for controlling viscosity as needed. As the concrete example of the monomers, such as Aronix* M150 and Aronix* 5700 (abopve made by Toa Gosei), and Kayarad* HX620, Kayarad* TMPTEA and Kayarad* TC110S (above made by Nippon Kayaku), and they need to be compatible with above described hardening resin, therefore, they are used by appropriately selected. Further, small amount of surface active agent, mold release agent, etc. may be added to the hardening resin 4. By adding the surface active agent it is able to further increase the flow of the resin compound, and further it provides low bubbling property, bubble suppressing property, and high wetting property, which improves easiness of handling and is able to minimize the shoulder thickness of the valley sections of later described pattern relief layer as well, at the same time. As the concrete examples of the surface active agent, it is able to mention such as Florad FC430, Florad FC431 (above made by 3M), and Modaflow* (made by Monsanto). As the mold releasing agent, above described ones may be similarly used, and by adding these mold releasing agent, it is able to make the releasing of hardened resin from the master pattern and able to reduce residual stress at releasing from the mold.

** Translator's note: All these brand names are phonetic translation and the original spellings in English are not certain.*

At first, the method of this invention places the hardening resin 4 for resist between the master pattern 1 and the substrate 3, and applies pressure on the both sides of the master pattern 1 and the substrate 3 with appropriate pressurization means, so that the hardening resin 4 expands into thin and uniform thickness while being in a sandwiched condition between the master pattern and the substrate.

Placing of the hardening resin 4 may be done by dripping on the master pattern, for example,

and as the above described means of pressurizing, it is able to apply such as a pressurizing method with pressurizing plates as shown in Figure 2 (c) as well as the roll pressurization method as shown in a drawing in Figure 1 (b). As the means for pressurizing, the method to press with holding press plates 10 from top and bottom is the simplest, however, a roll pressurization method, that is to nip between two pressure rolls 11 spaced in constant distance and rotate the rolls while applying a pressure, is desirable from the standpoint that it is able to apply uniform pressure. The hardening resin 4 is dripped normally at the center of the master pattern 1 (refer to Figure 2 (a)), however, when the roll pressurizing method is applied, dripping at near one end of the master pattern 1 (refer to Figure 1 (a)) is desirable for uniformly spread the resin 4. In the method of this invention it is important to handle in the operation of sandwiching said hardening resin 4 that bubbles would not be entrapped in the resin compound. As the countermeasure for this, for example, the master pattern is placed horizontally, after dripping the resin 4, the substrate 3 is held above the master plate 1 slightly inclined from the horizontal, then the substrate 3 is slowly lowered and when one end of the substrate almost touches the master pattern 1, opposing other end is further lowered to hold in parallel condition to the master pattern. At this time, the resin 4 starts to expand on the surface of the valleys of the master pattern while contacting with the substrate 3 and being sandwiched. After this, it may be pressed on both sides, master pattern 1 and substrate 3, to further expand the resin 4 and make its thickness uniform. In order to apply uniform pressure on the surfaces of the master pattern and the substrate, a method to apply air pressure on both side, the master pattern 1 and the substrate 3, or a method to make the inside that is sandwiched between the master pattern and the substrate in a condition of reduced pressure and uniformly pressurize using the pressure of atmosphere, may be used, or these methods may be used together.

Then, heat or electromagnetic radiation 5 is irradiated to cure the hardening resin 4 that is sandwiched between the master pattern 1 and the substrate 3.

This irradiation is done through the side of master pattern and/or substrate where the heat or electromagnetic radiation is able to transmit or pass. As the electromagnetic radiation, such as ultraviolet light and electron beam may be used, and ultraviolet light is desirable from the standpoint of easy application. As the ultraviolet light source, such as a super high pressure mercury vapor lamp, a high pressure mercury vapor lamp and a metal halide lamp, may be used. For example, sufficient curing is able to be done with high pressure mercury vapor lamp at the wave length of 365 nm and energy of about 1 J/cm^2. Further, the irradiation on the hardening resin 4 for curing is more desirable to be done simultaneously while applying said pressurization for controlling the thickness of the hardening resin, and for example, in case of applying roll pressing, it is better to design the application of curing by immediately irradiating ultraviolet light directly after passing through the rolls. Further, there are cases that heat is also irradiated from a light source when irradiating ultraviolet light, therefore, in order to prevent the reduction of dimensional accuracy of pattern by thermal expansion of the master pattern 1 and the substrate 3 due to heating with this heat, there is a need to control heat radiation by using such as a cold mirror as necessary.

Then after curing the hardening resin 4, the master pattern 1 is released from the surface of the substrate 3.

This releasing may be very easily done if either one or both of the master pattern 1 and the substrate 3 are flexible material, however, if both are stiff material such as glass, it can not be easily done unless the boundary between the master pattern 1 and the hardening resin is release treated ahead of time. The releasing treatment is done by either coating releasing agent such as

silicone oil on the side of valley sections 2 of the master pattern 1, or by adding to the hardening resin 4. Also for releasing stiff materials on both sides, it is better to fix backsides of the master pattern 1 and the substrate 3 to jigs such as suction cups as shown in Figure 2 (d), and gradually release from one end of the master pattern 1 or the substrate 3 by pulling the jigs. In this case, smoother releasing is possible if high pressure air is blown into the releasing gap when one end has started to slightly release.

By the above described releasing, the hardened resin layer is removed from he master pattern 1 side and adheres/transfers to the substrate 3 side, and as a result, a patterned relief layer 6 is formed that comprises cured resin that is formed by the master pattern 1 on the substrate 3 (refer to Figure 1 (d) and Figure 2 (d)). Because the step height of the pattern in the relief layer 6 is almost exact replica of the steps of the master pattern 1, therefore, control of the pattern step height is able to be done by the pattern of the master pattern alone, namely by the adjustment of the valley sections 2. Further, the thickness of the relief layer 6 , especially the layer thickness of the valley section 8 is able to be appropriately controlled with viscosity, wetting property and dripping amount of the hardening resin 4 and pressurizing condition of the master pattern and the substrate.

This invention at last applies etching, which is uniform across entire surface of the valley sections 8 and peak sections 9 of the relief layer, to the substrate 3 that has been formed with the pattern relief layer 6. By this etching, cured resin is completely removed only at the valley sections 8 of the relief layer as shown in Figure 1 (e) and Figure 2 (e), and the cured resin at the relief layer peak sections 9 would be also removed at the same amount with the valley sections 8, however, a part of it remains and a resist layer 7 comprising this remaining part of the cured resin is formed on the substrate 3.

For the above described etching, it is able to apply an etching method that does using chemical or solvent depending on the composition of the hardening resin, however, because there are many cases that the hardening resin layer would cause swelling prior to being dissolved in chemical or solvent with the ordinary hardening resins, and locations with thick layer and locations with thin layer would both similarly swell which causes deformation of the pattern shape of the relief layer, therefore, there is a problem that it is difficult to selectively and completely dissolve and remove only the valley sections of the relief layer where the thickness is thin, which is required by this invention.

Therefore, it has been confirmed that the dry etching method is the most desirable for said etching by the result of investigation by the inventors and others. With this dry etching method, surface of organic substance that is a object of etching evaporates by reacting with active gas (oxygen plasma for example), therefore, etching is done in sequence from the surface side of the material to be etched. This invention utilizes this feature ant it is able to gradually proceed etching in the direction of film thickness from the surface of the cured resin layer of the relief layer 6, and furthermore, because its rate of etching is constant regardless the valley sections or peak sections of the relief layer, it is able to completely remove the cured resin at only the valley sections 8 of the relief layer where the film thickness is thin, as a result, and partially leave the cured resin at the peak sections 9 of the relief layer where the film thickness is thick. As the dry etching method, plasma etching method and a etching method by ozone oxidation are mentioned.

In order to be able to form a good resist layer 7 with above described etching of relief layer 6 in this invention, it is important to form a patterned relief layer 6 wherein the ratio of film thickness A of peak sections 9 and film thickness B of valley sections A of the relief layer (A/B) is 1.2/1 or greater. When the ratio of film thickness is smaller than said value range, it is difficult

to apply an etching treatment that completely removes the cured resin at the valley sections 8 only but partially leaves the cured resin at the peak sections 9, and in a chemical etching method, there is a problem that especially if difference in dissolving property between the valley sections 8 and peak sections 9 is small, the cured resin at 8 and 9 will be dissolved together and removed. Further, when the dry etching is applied, the step between the peak and valley of the relief layer may be a difference of sub-micron, if the area of etching treatment is small, and for example in the etching of treatment area of 1 cm x 1 cm, forming of resist is possible even at a difference of 0.2 μm, however, if treating area is larger, it is necessary to set the difference of the peak and valley to be greater.

The substrate 3 formed with a resist pattern by the method of this invention is completed with desired pattern forming to the substrate 3 by applying an ordinary etching treatment after this and finally removing the resist layer 7.

The forming method of resist pattern of this invention is applicable as a pattern forming method for making various products that require forming of micro fine resist patterns, as well as for forming micro fine resist patters for producing semiconductors.

In the following, this invention is further explained in detail mentioning concrete embodiment examples.

Embodiment example 1

Forming of a resist pattern is done following an embodiment example that is shown in drawings in Figure 1.

At first, using the one formed with 2 μm deep valleys of relief pattern on a polycarbonate substrate of 15 cm in length and width and 0.3 mm in thickness with photo-polymer method using ultraviolet light hardening resin as the master pattern 1, an ultraviolet light curing resin compound 4 was dripped with flow coating method on the left side (side of roll 4*) of this master pattern (Figure 1 (a)). This resin compound is a resin compound prepared by mixing in a ratio of 30 weight percent of IPDI base urethane type acrylate resin (Goselak** UV 7000B, made by Nippon Gosei) as oligomer, and 70 weight percent Kayarad** FHX220 (made by Nippon Kayaku), and further adding 2 weight percent of Irgacure** 184 (made by Ciba Geigy) as photo-initiator and adjusted to 180 cps of viscosity.

** Translator's note: This "roll 4" shall be an apparent mistake of "roll 11".*

*** Translator's note: All these (brand) names are phonetic translation and the original spellings in English are not certain.*

Using a substrate 3 which is coated with indium oxide (ITO) on a glass substrate to be 10 Ω/□ of film in 1 mm thickness, this substrate 3 was mounted over a master pattern 1 from the top, and the pressure roll 11 was rolled toward right direction in the drawing at a velocity of 50 cm/min. to apply pressure (Figure 1 (b)). At this time air bubbled that exist between the master pattern 1 and the substrate 3 is expelled at a point shown by P in the drawing. Also, ultraviolet light was irradiated at 160 W/cm^2 immediately after applying roll pressing using an ultraviolet light source, to cure the ultraviolet light hardening resin 4 (Figure 1 (c)).

Then the master pattern was released after removing the pressure to form a patterned relief layer 6 on the substrate 3 (Figure 1 (d)). This relief layer had a pattern step in 2 μm, thickness of the valley sections in 1 μm and thickness of peak sections in 3 μm.

Finally, the relief layer was dry etched with oxygen plasma to completely remove the hardened resin at the valley sections, and a resist layer 7 which is in identical pattern shape with the pattern of the peak sections 9 of the relief layer was able to obtain. The cured resin at the peak section 9 was similarly etched with the valley sections 8 and film thickness was reduced to

2 μm at last.

By etching the substrate 3 that is formed with the resist pattern with iron chloride type etching solution and removing the resist layer, an ITO layer comprising the same pattern with the resist layer 7 was able to be obtained.

Embodiment example 2

Forming of a resist pattern is done following an embodiment example that is shown in drawings in Figure 2.

At first, surface of glass substrate of 30 cm in length and width and 3 mm in thickness was etched to valley sections of a specific pattern in 3 μm deep with photo-lithography method , and then silicone oil (made by Toho Chemical, Gafack* RE410) was coated on the surface as the releasing agent to make a master pattern 1, and the ultraviolet curing resin compound 4 that is the same as the embodiment example 1 was dripped at the center of this master pattern (Figure 2 (a)).

Then, the glass substrate 3 having an ITO layer that is the same as the embodiment example 1 was mounted slightly in inclined position and gradually pressed against the master pattern 1 (Figure 1 (b)). At this moment, air bubbles existing between the master pattern 1 and the substrate 3 are expelled at the points shown by P in the drawing.

Then with a pressure plates 10, 10 the master pattern 3* and the substrate 1* were pressed from the top and bottom. A part of the bottom pressure plate was constructed with transparent glass where it contacts with the master pattern 1 and the resin compound 4 was cured by irradiating ultraviolet light at 160 W/cm** through the bottom pressure plate for 30 seconds at the same time with pressing (Figure 2 (c)).

**Translator's note: These "master pattern 3" and "substrate 1" shall be mistakes of "master pattern 1" and "substrate 3" respectively.*

***Translator's note: This "cm" shall be a mistake of "cm^2".*

After the curing, the pressure was removed and both were released while backsides of the master pattern 3* and the substrate 1* were suctioned with suction cups 12, and a pattern relief layer 6 was formed on the substrate 3 (Figure 2 (d)). This relief layer had a pattern step in 3 μm, thickness of the valley sections 8 in 1 μm and thickness of peak sections 9 in 4 μm.

**Translator's note: These "master pattern 3" and "substrate 1" shall be mistakes of "master pattern 1" and "substrate 3" respectively.*

Finally, the relief layer was dry etched with oxygen plasma to completely remove the hardened resin at the valley sections 8, and a resist layer 7 which is in the pattern of the peak sections of the relief layer was able to be obtained (Figure 2 (e)). The cured resin at the peak section 9 was similarly etched and film thickness was reduced to 2 μm at last.

Embodiment example 3

Forming of a resist pattern was done following an embodiment example that is shown in Figure 2.

At first, oligo-ester-acrylate type ultraviolet light curing resin compound 4 was dripped at the center of a master pattern 3 that is the same as the embodiment example. This resin compound 4 is 98 weight percent of Kayrad** TMPTA (made by Nippon Kayaku) added with 2 weight percent of Irgacure** 184 (made by Ciba Geigy) as photo-initiator.

**Translator's note: This "master pattern 3" sahll be a mistake of "master pattern 1".*

***Translator's note: All these (brand) names are phonetic translation and the original spellings in English are not certain.*

Then, the glass substrate 3 having an ITO layer 13 that is the same as the embodiment

example 1 was mounted slightly in inclined position and gradually pressed against the master pattern. Then the master pattern and the substrate were pressed with the same means of pressing witht he embodiment example 2, and at the same time the ultraviolet light curing resin 4 was cured by irradiating ultraviolet light at 160 W/cm* through the bottom pressure plate for 30 seconds.

**Translator's note: This "cm" shall be a mistake of "cm^2".*

Then as same as the embodiment example 2, the master pattern 3* and the substrate 1* were released by using suction cups, and a pattern relief layer 6 was formed on the substrate 3. This relief layer had a pattern step in 3 μm, thickness of the valley sections in 1 μm and thickness of peak sections in 4 μm.

**Translator's note: These "master pattern 3" and "substrate 1" shall be mistakes of "master pattern 1" and "substrate 3" respectively.*

Finally, the substrate having the relief layer was etched in 2 % water solution of caustic soda to remove the cured resin at the valley section of the relief layer, and a resist layer was obtained. At this time the cured resin at the peak sections was also etched and the film thickness was reduced to 3 μm.

[Effect of the invention]

As above explained, according to this invention, it is able to form fine and highly precise resist patterns which is comparable with previous photo-lithography method, and it is not necessary to use an expansive and complicated equipment that is used in the photo-lithography method when making a pattern, and further, it is able to be done with relatively simple and less and short process steps without complicated controls, therefore, it is able to form resist patterns easily and in high precision and high efficiency, compared to previous method. Further, if the layer thickness of peak sections and valley sections of the patterned relief layer that is formed in a substrate is set at the specific ratio as described above, forming of securer and clearer resist patterns in better repeatability is enabled.

4. Brief explanation of drawings

Figure 1 is a cross sectional explanation drawing of each process showing an embodiment example of the method of this invention, and Figure 2 is a cross sectional explanation drawing of each process showing another embodiment example of the method of this invention.

1: master pattern, 2: valley section, 3: substrate,
4: hardening resin for resist,
5: heat or electromagnetic radiation,
6: patterned relief layer, 7: resist layer
8: relief layer valley section, 9: relief layer peak section

Assignee: Dainippon Printing Co., Ltd.
Attorney: Isamu Hosoi, Patent attorney

Figure 1

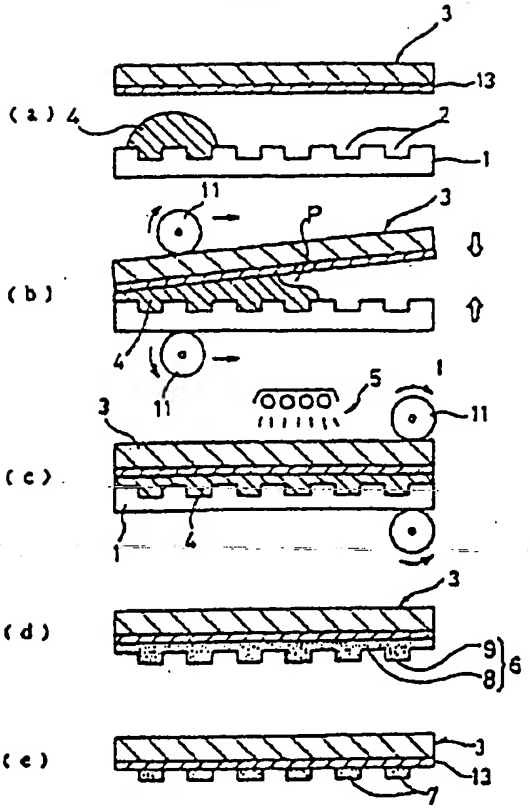
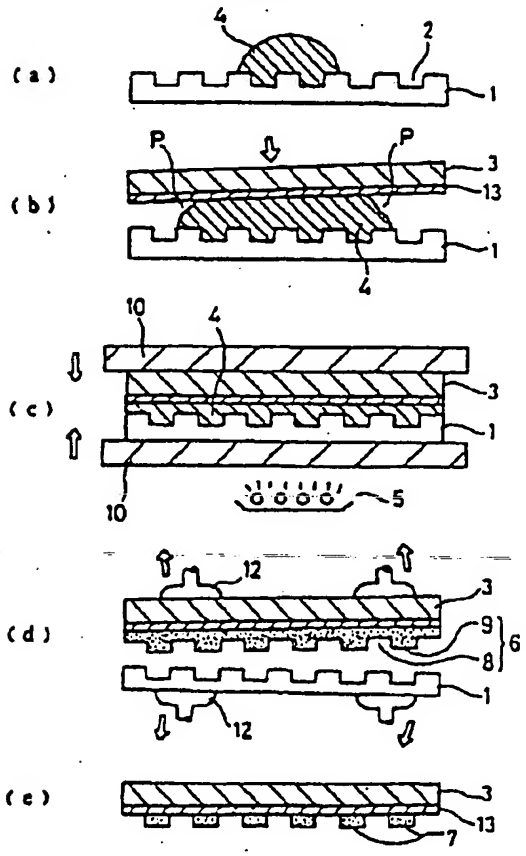


Figure 2



1: master pattern, 2: valley section
3: substrate, 4: hardening resin for resist
5: heat or electromagnetic radiation, 6: patterned relief layer,
7: resist layer, 8: relief layer valley section

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